TECHNICAL REPORT

Office of Naval Research
Engineering Psychology Branch
Contract N00014-71-C-0354
Work Unit Number NR 197-002

CONVENTIONAL AND HIGH FREQUENCY HEARING OF NAVAL AIRCREWMEN AS A FUNCTION OF NOISE EXPOSURE

Principal Investigator John L. Fletcher, Ph.D.

1 April 1972

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

Memphis State University
Dept. of Psychology
Memphis, Tennessee 38111

UNCLASSIFIED

Conventional and High Frequency Hearing of Naval Aircrewmen as a Function of Noise Exposure

Technical Report May, 1971 - March, 1972

John L. Fletcher

1 April 1972

5

N00014-71-C-0354

HRL/1

Unlimited. Qualified requesters may obtain copies from the Defense Documentation Center, Cameron Station, Alexandria, Virginia. Others should contact the author at Dept. of Psychology, Memphis State University, Memphis, Tennessee 38111.

Engineering Psychology Branch
Office of Naval Research
Washington, D.C.

Conventional and high frequency audiograms for US Navy Prop, Jet, and Rotary wing pilots were obtained and plotted as a function of amount of flight time logged. Lack of sufficient audiograms of Prop and Rotary pilots restricts discussion of the relative hazard to hearing of Prop, Rotary, and Jet flight. However, for Jet aircrewmen, losses appear to begin at the higher frequencies i.e., above 6 KHz, and erode with cumulative flight time down to the lower frequencies. Percent of persons detecting the high frequency signals is a more precise index of the progression of hearing loss than is mean hearing level, primarily because of an artifact in scoring audiograms. Data collection of aircrew candidates pre-training, during training, and post-primary hearing are concurrently being collected by US Navy Aerospace Medical Research Institute (NAMI) personnel at Pensacola NAS. These data will be incorporated into the final report of this joint MSU-NAMI project. (U)

DD FORM 1473

UNCLASSIFIED

Security Classification

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Hearing loss						
Noise exposure						
Hearing conservation						
High frequency hearing						
Audiometry						
Audition						
Noise induced hearing loss						

DD FORM 1 NOV 65 1473 (BACK)
(PAGE 2)

UNCLASSIFIED
Security Classification

CONVENTIONAL AND HIGH FREQUENCY HEARING OF NAVAL AIRCREWMEN AS A FUNCTION OF NOISE EXPOSURE*

John L. Fletcher
(Department of Psychology, Memphis State University)

The direct and indirect effects of noise on man have been documented in great detail. The costs to industry and to the government are staggering. Because noise induced hearing losses are gradual in both onset and progress, and in view of the fact that protective devices and procedures to reduce or eliminate noise induced hearing losses are well known and readily available, early detection of noise induced hearing losses should help in institution of protective measures that would eliminate or minimize occupational hearing loss.

It is known that, in general, noise induced hearing losses begin at higher frequencies and erode gradually down into the lower frequencies, the so called speech frequencies, where they result in loss of ability to understand or detect speech. These losses of ability to communicate result in both a social and an economic loss to the person incurring the hearing deficit.

Until recently, measurement of hearing at frequencies above about 8000 Hz was unreliable, primarily because of the difficulties in coupling the ear and the transducer. Coupling at high frequencies is extremely critical because of the short wave length of high frequency waves, therefore placement of earphones upon the head was critical and if placement varied from test to test threshold would vary from test to test. Dr. Wayne Rudmose found a solution to this problem, however, and devised a reliable high frequency audiometer. His solution, simple and effective, was to use a capacitor microphone inserted into the ear canal as the transducer in lieu of earphones. Fletcher (1965) found that the Rudmose high frequency hearing audiometer produced more reliable audiograms at comparable frequencies than did a conventional audiometer and that reliability of high frequency audiograms was sufficiently high that such tests could be useful. Later research of

*Research supported by ONR Contract No. N00014-71-C-0354. The statements here made are those of the author and do not necessarily reflect those of the US Navy.

high frequency hearing (Northern, et al. 1971) has resulted in standards for the high frequencies being recommended. Studies have been made of the relation of high frequency hearing to age and sex (Zislis and Fletcher, 1966), of high frequency hearing of meningitis patients (Fletcher, et al. 1967), and of high frequency hearing and ototoxic drugs (Jacobson, et al. 1969). The studies cited found high frequency hearing to be a sensitive indicator of trauma to hearing from meningitis and from ototoxic drugs, and showed that information could be gained from testing high frequency hearing that would not be available through testing confined to conventional frequency limits. These results suggest that high frequency hearing might be a sensitive indicator of hearing loss from noise exposure in humans. If that is true, it might be possible by examining the high frequency hearing of those exposed during work to potentially hazardous noise, to detect hearing loss from noise exposure early in its inception, and by early detection, institute appropriate protective measures to minimize occupational hearing loss.

It is therefore the objective of this project to study the hearing of US Naval aircrewmen from the beginning of their aircrew training through their flying career with the aim of determining the onset and progress of hearing loss as a function both of hours of flight time and of type of aircraft flown.

METHOD

Hearing was tested at the frequencies 500, 1,000, 2,000, 3,000, 4,000, and 6,000 Hz using an ARJ - 4A Rudmose Audiometer. Testing at 8,000, 9,000, 10,000, 11,000, 12,000, 13,000, 14,000, 15,000, 16,000, and 18,000 Hz was accomplished with an ARJ - 4HF Rudmose Audiometer. All testing was done in IAC booths meeting appropriate ANSI standards Aircrew candidates will be given a reference audiogram at Naval Aerospace Medical Institute, Pensacola, Florida, facilities by NAMI personnel prior to beginning aircrew training, during training, and at the end of basic training. Testing thereafter was done at Millington NAS, Tennessee, and Meridian NAS, Mississippi. The log book of each qualified pilot was examined in detail for the number of hours of flight time and for the type of aircraft flown and the total flight time of each pilot was recorded and, based on the type of aircraft most flown, the record was judged to be jet, prop, or rotary wing flight. After examination of the log books, pilots were contacted, scheduled, and called in and tested. At time of test, each pilot was at least 16 hrs. post-exposure from significant noise exposure. The calibration of each audiometer was checked biologically prior to testing, periodically during testing, and after testing by the technicians using the biological technique. An artificial ear was used to check calibra-

tion of the ARJ - 4A about every two months during the testing period, or as the need was felt to check calibration. All tests were conducted by properly trained and qualified persons.

All S's were commissioned Navy pilots, on active duty, with varying amounts of flight time. Scheduling of pilots was accomplished by working in co-operation with the Senior Medical Officer - Flight Surgeon at each installation, and through him, the commanding officers of the various flight activities.

RESULTS

The results of incomplete testing to date are shown in Figures 1-4. The figures as shown are somewhat misleading. At the high frequencies, or at any frequency for that matter, when a S could not hear a signal, he was given the numerical value of the highest level possible at the frequency, i.e., 70 dB on the high frequency audiometer. For the higher frequencies, then, it is important not only to look at the mean hearing level, but also at the percent of S's taking the test who could hear a given frequency. Figure 5 shows the percent of S's hearing (i.e., detecting the specific frequency and not being assigned the maximum level).

In Figure 5 we can see much better the progression of hearing loss in pilots as a function of hours of flight time than is revealed in Figures 1-4. Note for example the erosion of high frequency response from 100% at 6 KHz to less than 50% at 18 KHz in the Class I-IV Jet Pilots. A rather clear and marked decrease in percent responding, going in frequency downward, and at each frequency, getting progressively worse with hours of flight time. Thus, in Jet pilots, it seems we very well may be able to detect high frequency hearing losses rather early in the career of the pilot and, with initiation of appropriate testing and protective measures, at least slow down the gradual erosion of hearing loss into the critical speech region frequencies so vital for communications.

Not a great deal can be said about Prop and Rotary pilots because of the relative paucity of data collected to date. However, the worst (i.e., longest flying) Prop pilots appear to be less able to hear than the worst Jet pilots, both in terms of lower mean hearing levels (see Figures 2 and 3) and in terms of a lower percent of pilots hearing the higher frequencies.

The Rotary and Jet VI pilots seem to be fairly close, although the number of Rotary pilots and the amount of flight time are such that no legitimate comparison can be made.

Closer examination of Figures 1 and 2 shows that Jet groups I through III, with accumulated flight hours of from 58-795, are very close together with regard to both mean hearing levels and percent responding to the higher frequency signals. However, more "spread" can be observed in both mean hearing level and in percent responding.

DISCUSSION

The data from the Jet pilots show rather clearly what it had been suspected they would, that hearing losses begin at higher frequencies, eventually degrading perception of speech. This, of course, would affect the performance of pilots, who must rely heavily upon speech communications in performance of their mission. The data also show that mean hearing levels a-lone are not a true indicator, or at least not a precise index, of hearing loss. This is true because the highest score that can be given to one who does not perceive a signal is simply the maximum level possible at the frequency with the audiometer used. Thus, it is necessary to know not only mean level, but for the frequencies above 6 KHz at least, the percent of S's perceiving the signal.

So far, no firm conclusions can be reached regarding the relative hearing hazards of Jet, Prop, and Rotary wing noise exposure. Much more data will have to be accumulated on Prop and Rotary wing flyers in order to properly evaluate the hazards to which they are exposed.

The data in the process of collection at NAMI, Pensacola, will be invaluable in telling us of the hearing hazards of basic training and establishing for the high frequencies an initial level for those entering training. Data are also needed for advanced specialized training and plans are made for testing of those necessary to fill the gaps in our knowledge. When all the data are in, we should be able to begin with entry into flight training and follow the hearing of aviators through basic and advanced flight training, and then through a career as a Jet, Prop, or Rotary pilot or indeed, as a pilot flying combinations of one or more types of aircraft. We should also be able to point out crucial ages or points in the career of the flyer which in turn would suggest preventive measures or procedures to prolong the hearing and therefore the effectiveness and useful career of the flyer.

REFERENCES

1. Fletcher, J.L., Reliability of high frequency thresholds. J. aud. Res., 1, 133-137.

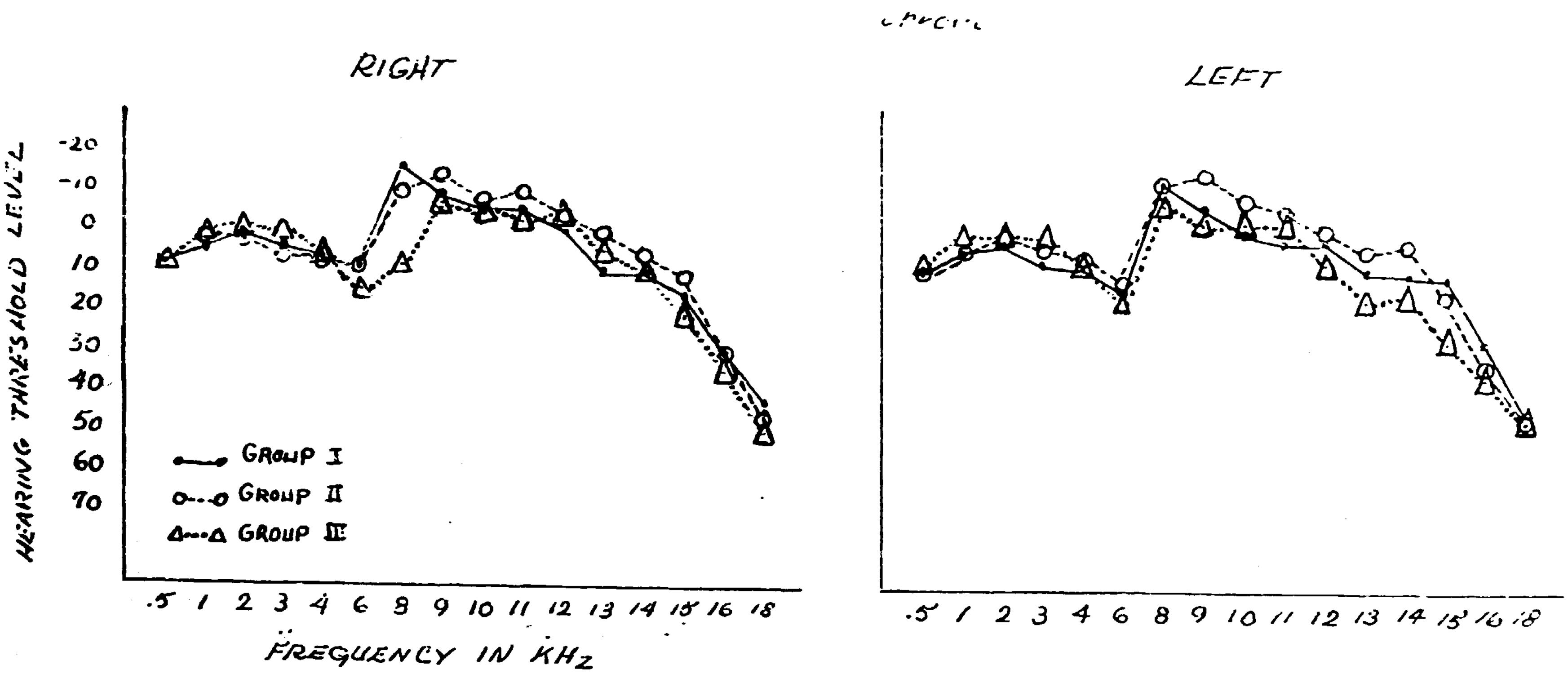
2. Zislis, T., and J.L. Fletcher. Relation of high frequency thresholds of age and sex. J. aud. Res., 1966, 6, 189-198.

3. Fletcher, John L., Cairns, Adrian B., Collins, Fred G., and Endicott, James. High frequency hearing following meningitis. J. aud. Res., 1967, 7, 223-227.

4. Jacobson, Edward J., Downs, Marion P., and Fletcher, John L. Clinical findings in high frequency thresholds during known Ototoxic drug usage. USA Med. Res. Lab. Rep. 820, 25 March 1969.

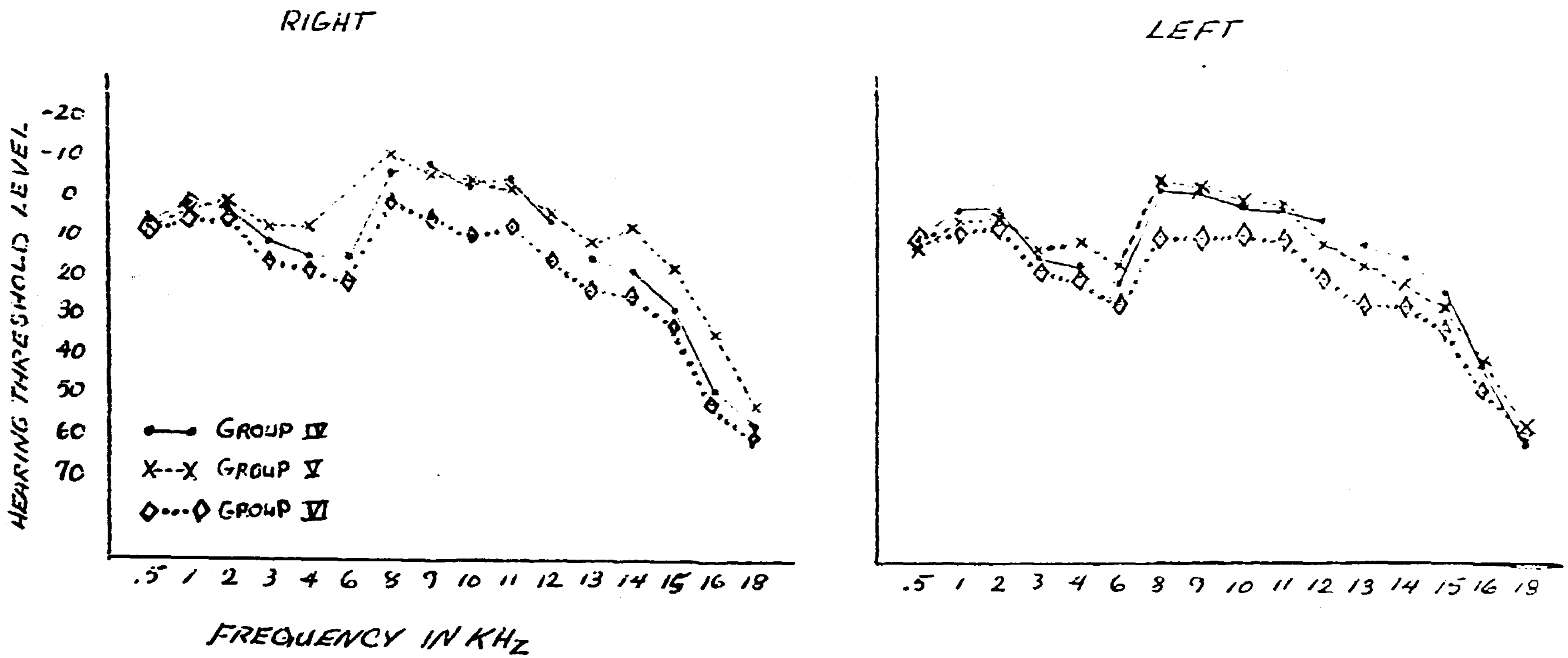
5. Northern, Jerry L., Downs, Marion P., Rudmose, Wayne, Glorig, Aram, and Fletcher, John L. Recommended High Frequency Audiometric Threshold Levels. J. Acoust. Soc. Amer. (in press).

FIGURE 1. Audiograms, Right and Left Ears, Jet Pilots Categories I - III



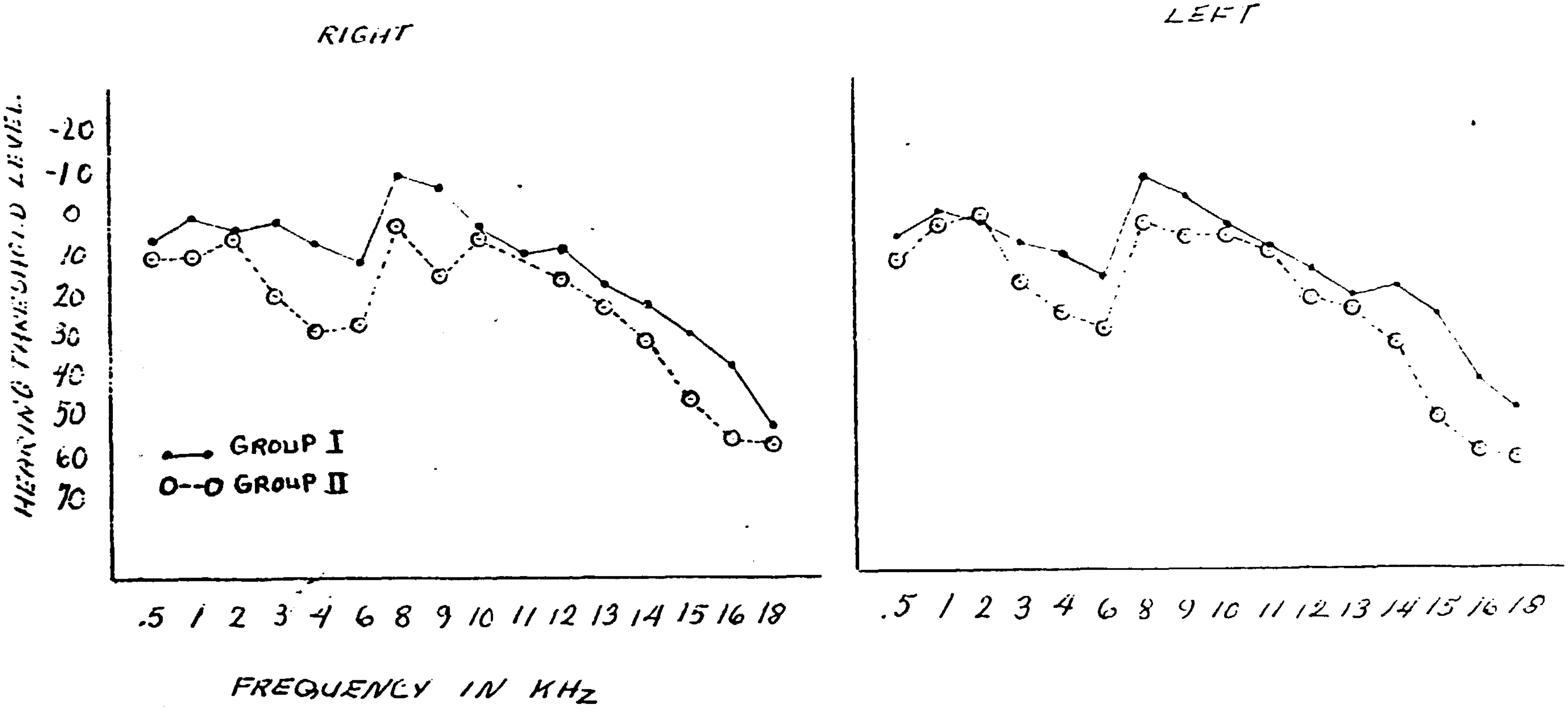
Group I - N=22, 58-299 hours flight time.
Group II - N=22, 300-544 hours flight time.
Group III - N=18, 565-795 hours flight time.

FIGURE 2. Audiograms, Right and Left Ears, Jet Pilots Categories IV - VI



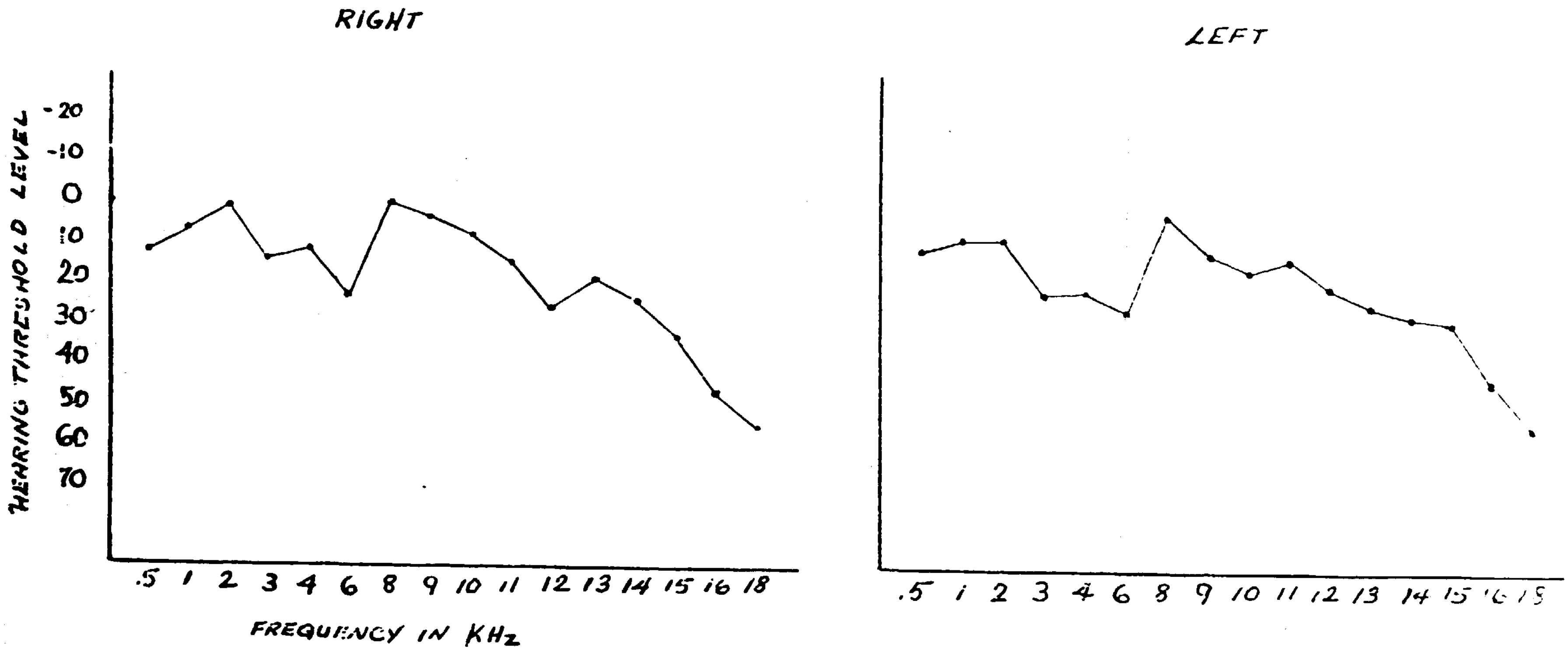
Group IV - N=20, 800-988 hours flight time.
Group V - N=23, 1020-1483 hours flight time.
Group VI - N=25, 1500-3767 hours flight time.

FIGURE 3. Audiograms, Right and Left Ears, Prop Pilots



Group I - N=19, 502-1900 hours flight time.
Group II - N=18, 2573-9326 hours flight time.

FIGURE 4. Audiograms, Right and Left Ears, Rotary Wing Pilots



N=8, 575-3733 hours flight time.

FIGURE 5. Percent Response by Frequency, Right and Left Ears, Jet, ..u Rotary Pilots